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Application of Straight-needle, Three-tailed, Knot-free, Peritoneal Sutures in Laparoscopic Transabdominal Preperitoneal Hernia Repair

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TITLE:

Application of Straight-needle, Three-tailed, Knot-free, Peritoneal Sutures in Laparoscopic Transabdominal Preperitoneal Hernia Repair

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KEYWORDS:

Laparoscopic; TAPP; peritoneal suture

SUMMARY:

Here, we present a protocol to introduce a new peritoneal suture method. This method is called straight-needle, three-tailed, knot-free suture, and we will outline the manufacturing method and clinical application of this suture in detail.

ABSTRACT:

Laparoscopic transabdominal preperitoneal hernia repair (TAPP) is one of the most widely used methods in inguinal hernia surgery. After the mesh is placed, the peritoneum must be resutured to avoid contact with the tissues and organs in the abdominal cavity. If the peritoneal suture time is too long, the operation and anesthesia time will be prolonged, increasing the burden on the patient. Moreover, improper suture methods cause serious consequences, such as intestinal obstruction

and mesh infection.

The straight-needle suture method transforms the three-dimensional spatial configuration of the needle holder and the arc needle tip into a two-dimensional planar structure, which greatly reduces the difficulty of suturing. The three-tailed knot can be anchored at the beginning of the suture by its friction and button effect, which has an exact fixation effect. Thus, the suture does not easily slip, and the time to complete the suturing is shortened. Compared with the traditional suture method, the operator can suture the peritoneum more quickly, beginners can pass through the difficult learning curve faster, and skilled operators can also shorten the total operation time of TAPP to a certain extent. Thus, this suture method is extremely amenable to clinical application.

INTRODUCTION:

Laparoscopic transperitoneal preperitoneal hernia repair is the main method of inguinal hernia repair[1]. This approach has a short learning curve, allows complete observation of the inguinal anatomy, and is widely applied in the clinic[2,3]. However, this operation requires a peritoneal incision, and after the placement of the mesh, the peritoneum must be sutured to prevent direct contact between the mesh and the organs in the abdominal cavity and avoid complications such as mesh erosion or adhesive intestinal obstruction[4,5].

There are many methods for peritoneal suture. At present, the traditional clinical method is to use absorbable sutures with continuous suturing. As the incised peritoneum is located in the anterior abdominal wall, the angle of the suture needle needs to be continuously adjusted during suture, and knots need to be tied at the beginning and end of each suture[6]. This suture method requires more time and more skilled endoscopic skills, and beginners require an extended practice period[7,8].

Thus, we designed a new method to improve the suturing process using straight-needle, three-tailed, knot-free sutures. The basic principle of this method is to use the two-dimensional structure of the straight needle and the anchoring effect of three knot-free tails in the process of suture to reduce the number of steps and the difficulty of suture. Having used this suture many times and compared it to the traditional method, we determined that this method is simple, easy to learn, safe and effective, with a low incidence of complications, and convenient for clinicians to use.

PROTOCOL:

The protocol was carried out in accordance with the tenets of the Declaration of Helsinki and approved by the ethics review committee of the Sixth Affiliated Hospital of Sun Yat-sen University.

1. Data and grouping

NOTE: From December 2018 to December 2020, laparoscopic TAPP was performed during gastrointestinal, hernia, and abdominal surgery at the Sixth Affiliated Hospital of Sun Yat-sen University. A total of 264 patients with inguinal hernia met the criteria and were included in the study.

1.1. Select adult and unilateral inguinal hernia patients for the surgery.

1.2. Apply the following exclusion criteria: recurrent hernia and bilateral hernia; incarcerated or strangulated hernia; other diseases such as ascites, connective tissue disease, heart/kidney failure, and hypoproteinemia; and the use of aspirin, clopidogrel, or other drugs that affect coagulation function.

1.3. Divide the patients randomly into an experimental group and a control group.

NOTE: In this study, 134 cases were assigned to the experimental group and 130 cases to the control group. The general conditions of the two groups, including age, sex, BMI, hernia type, and hernia sac treatment, are shown in **Table 1**.

1.4. Assign two groups of surgeons from the same team who have received standardized training to perform the surgery.

NOTE: In this study, the two groups of surgeons were experienced, laparoscopic surgeons. Ensure that there is no significant difference between the two groups ($P > 0.05$).

2. Method for generating the straight-needle, three-tailed knot

2.1. Straighten the needle of 3-0 VICRYL thread 1/2 round needle with an ordinary needle base.

2.2. Make the thread tail according to the sequence shown in **Figure 1A–F**.

2.2.1. Overlap two threads to make a single knot and then tighten the knot.

2.2.2. Pass one of the threads into the knot ring of the first knot.

2.2.3. Lay the tail at both ends against the first knot and then make the second knot.

2.2.4. Tighten the knot.

2.2.5. Leave the tail at one end of the needle (~12 cm long); cut off the ring and the tail at the other end. Ensure that the length of the remaining three tails is ~0.8 cm.

3. Suture method

3.1. Suture the control group continuously with a 12 cm long, conventional 1/2 circle curved needle and 3-0 VICRYL absorbable suture.

3.2. In the experimental group, make three knot-free sutures as described above, and suture the peritoneum continuously.

3.3. Sew the three tails of the straight needle into the peritoneum (**Figure 2A**).

3.4. Hold and fix the straight needle using forceps grasped in the left hand.

3.5. Press the straight needle directly into the upper and lower abdominal membranes (**Figure 2B**; approximately 0.8 cm needle pitch).

3.6. Repeat the above actions and sew 8-10 stitches continuously (**Figure 2C**).

3.7. Repeating the joint actions of grasping the forceps and holding the needle, tighten the 8-10 needles (**Figure 2D**) until the whole peritoneal incision is closed.

3.8. Tighten the suture after sewing (**Figure 2E**).

3.9. Tie or fix the end of the suture with an absorbable clip (**Figure 2F**).

4. Follow-up

4.1. Complete the postoperative follow-up with outpatient visits and telephone conferences for 3–24 months.

NOTE: The median follow-up time was 12 months in this study.

4.2. Record the occurrence of seroma, recurrence, and mesh infection.

5. Statistical analysis

5.1. Perform statistical analysis on peritoneal suture time, operation time, hernia recurrence, seroma, mesh infection, visual analog scale (VAS) score, length of hospital stay, and hospitalization expenses.

5.2. Express data as mean ± standard deviation (SD) and rates.

5.3. Compare the measurement data between groups using a *t*-test and the observation rate indices using a chi-square test.

5.4. Consider a difference to be statistically significant if $P < 0.05$.

REPRESENTATIVE RESULTS:

After the placement of the mesh, the incised peritoneum needs to be sutured again. Straight-needle, three-tailed, knot-free sutures were used for the peritoneal suture in the experimental group. The specific suture method has been described in detail in section 3 of the protocol (**Figure 2**). The control group was sutured with VICRYL suture or barbed suture with an arc needle. The two groups were compared with respect to suture times, operation times, hernia recurrence, mesh infection, seroma, VAS score, length of hospital stay, and hospitalization cost.

The peritoneal suture times of the experimental group and the control group were 5.5 ± 0.9 min and 11.7 ± 1.5 min, respectively, and the total operation times were 47.6 ± 2.8 min and 55.4 ± 2.3 min, respectively. There was a significant difference in both times between the two groups ($P < 0.05$). No recurrence of hernia was found in either group. There was no mesh infection in the experimental group and one mesh infection in the control group. The mesh infection was treated by color Doppler ultrasound-guided puncture and drainage in the groin area and systemic antiinfection treatment. The patient recovered after two weeks. During the follow-up period, two cases of seroma occurred in the experimental group and three cases in the control group. These seromas all subsided within 14 days after local symptomatic treatment. The local symptomatic treatment of postoperative seroma is the external application of mirabilite in the groin area.

There was no significant difference in postoperative visual analog pain score or length of hospital stay between the two groups ($P > 0.05$). The visual analog pain score is divided into four levels according to the score: 0 points for painless; 1–3 points: mild pain, which the patient can endure; 3–6 points: moderate pain that affects sleep but can be tolerated; 7–10 points for severe, unbearable pain. The hospitalization cost was 11435.6 ± 712.5 yuan for the experimental group and 11698.8 ± 733.3 yuan for the control group. There was a significant difference between the two groups ($P < 0.05$) (**Table 2**).

FIGURES AND TABLE LEGENDS:

Figure 1: Formation of suture knot of peritoneal incision in TAPP. (**A**) Overlap two threads to make a single knot and then tighten the knot. (**B**) Pass one of the threads into the knot ring of the first knot. (**C**) Lay the tail at both ends against the first knot and then make the second knot. (**D**) Tighten the knot. (**E**) Leave the tail at one end of the needle (about 12 cm long), cut off the ring and the tail at the other end. (**F**) The length of the remaining three tails is ~0.8 cm. Abbreviation: TAPP = transabdominal preperitoneal.

Figure 2: Detailed steps of application of straight-needle, three-tailed, knot-free

suture in TAPP. (**A**) Sew three-tailed suture into the side peritoneum. (**B**) Lift the upper and lower abdominal membranes with a claw in the left hand and press the straight needle with a needle distance of ~0.8 cm. (**C**) Press the upper and lower abdominal membranes continuously for 8–10 needles. (**D**) Tighten the suture with both hands. (**E**) End of suture. (F) Knot or fix the end. Abbreviation: TAPP = transabdominal preperitoneal.

Table 1: Comparison of general conditions between the two groups.
The main indicators of the general situation of the two groups of patients include age, gender, BMI, type of inguinal hernia, and treatment of hernia sac. Abbreviation: BMI = body mass index.

Table 2: Comparison of intraoperative and postoperative conditions between the two groups. The main indexes of intraoperative and postoperative conditions of the two groups include peritoneal suture time, operation time, hernia recurrence, seroma, mesh infection, VAS score, length of hospital stay, and hospitalization expenses. Abbreviation: VAS = visual analog scale.

DISCUSSION:
As the primary method of laparoscopic hernia repair, TAPP is widely used in the clinic. The main challenge in this operation is the suturing of the peritoneal incision. There is no standard suture method for the TAPP peritoneal incision. Some nonstandard methods lead to postoperative complications, such as inaccurate sutures and contact between the intestinal canal and mesh, resulting in postoperative intestinal adhesion and perforation; improper suturing or knotting; and intestinal canal invasion of the anterior peritoneum or suture ring, resulting in intestinal hernia and necrosis[9-11]. Reducing the cost of surgery and hospitalization and improving the quality of life of patients after surgery by shortening the peritoneal suture time has always been a challenge and a focus in the field of hernia surgery[12,13]. Compared with the traditional method, this straight-needle, three-tailed, knot-free suture method is easy to learn and master, and the suture is precise. This method can shorten the suture time and operation time and reduce the hospitalization cost.

TAPP peritoneal incisions are located in the lower abdominal wall. Due to the relationship between the patient's position and the angle of laparoscopy, the suture angle is different from that of standard laparoscopy. From this perspective, the suturing of this incision is similar to suturing on the vertical plane than it is to ordinary laparoscopic suturing. All stitching actions rely on the cooperation of both hands. The needle is held in a three-dimensional configuration with the needle tip if a curved needle is used. The right-hand operation covers a wide range, and the action is "three-dimensional." The needle holder and needle tip form a two-dimensional plane with a straight needle, and the right hand is only responsible for fixing the needle holder and sewing needle, which is a "two-dimensional action." According to the authors' experience, this two-dimensional action is much simpler

than the three-dimensional action. Therefore, the purpose of using a straight needle for this complex suture is to reduce the difficulty in suturing.

Knotting, especially on the abdominal wall, is a time-consuming and labor-intensive process, especially for beginners. Three-tailed sutures were designed to reduce the knotting time. In practice, fewer knots can reduce the suturing time by 1–2 min. Unlike the traditional barbed thread, the three-tailed thread is anchored at the beginning of the suture by its friction and button action, which has a good fixing effect. This thread does not easily slip and is not inferior to traditional direct knotting. In this study, there was no rupture of the peritoneal incision or contact between the mesh and abdominal tissues and organs due to thread knot slippage in either group. The three tail ends can be placed in the abdominal cavity or between the peritoneum and the mesh. While the two methods achieve the same suture effect, three-tailed sutures can greatly shorten the suture time.

In the process of suturing, the needle holder and straight needle are typically fixed with the right hand, and the upper and lower edges of the peritoneum are alternately grabbed by grasping forceps in the left hand and are then "pressed" into the straight needle. This action can be performed using 8–10 needles at a time. Then, the needle is pulled out with grasping forceps in the left hand, the suture is tightened with the needle holder, and the abdominal incision is closed by the friction of the suture. The following 8–10 stitches are sutured according to the above two-hand cooperation method. Compared with the control group, the time for straight-needle suture was shortened by 5–6 min. As the length of the upper and lower edges of each peritoneal incision was the same, a few more stitches were sutured in the lower edge of the peritoneum to make the remaining length of the peritoneum as consistent with the shorter upper edge of the peritoneum as possible. In the case of peritoneal rupture and perforation during suture, the perforated area was wrapped into the suture range as much as possible and the preperitoneal space separated to obtain a sufficient peritoneal width to reduce suture tension. When suturing the peritoneum, it is necessary to move gently to prevent the peritoneum from being torn.

This study revealed that straight-needle, three-tailed, knot-free sutures are simpler and easier to learn than the traditional method. The operators, especially beginners, can suture the peritoneal incision more quickly using this suture method. The time for beginners to master this method is ~1–3 months, and it is estimated that 30–40 cases of practical operation are required to reach the level of a skilled suture.
The learning curve is faster, and the use of this method can shorten the overall TAPP surgery time and reduce patient medical expenses for skilled operators. Additionally, the efficacy of this suture method is the same as that of the traditional method. Hence, this suture method is suitable for broad clinical application.

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DISCLOSURES:

The authors have no conflicts of interest to disclose.

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Figure

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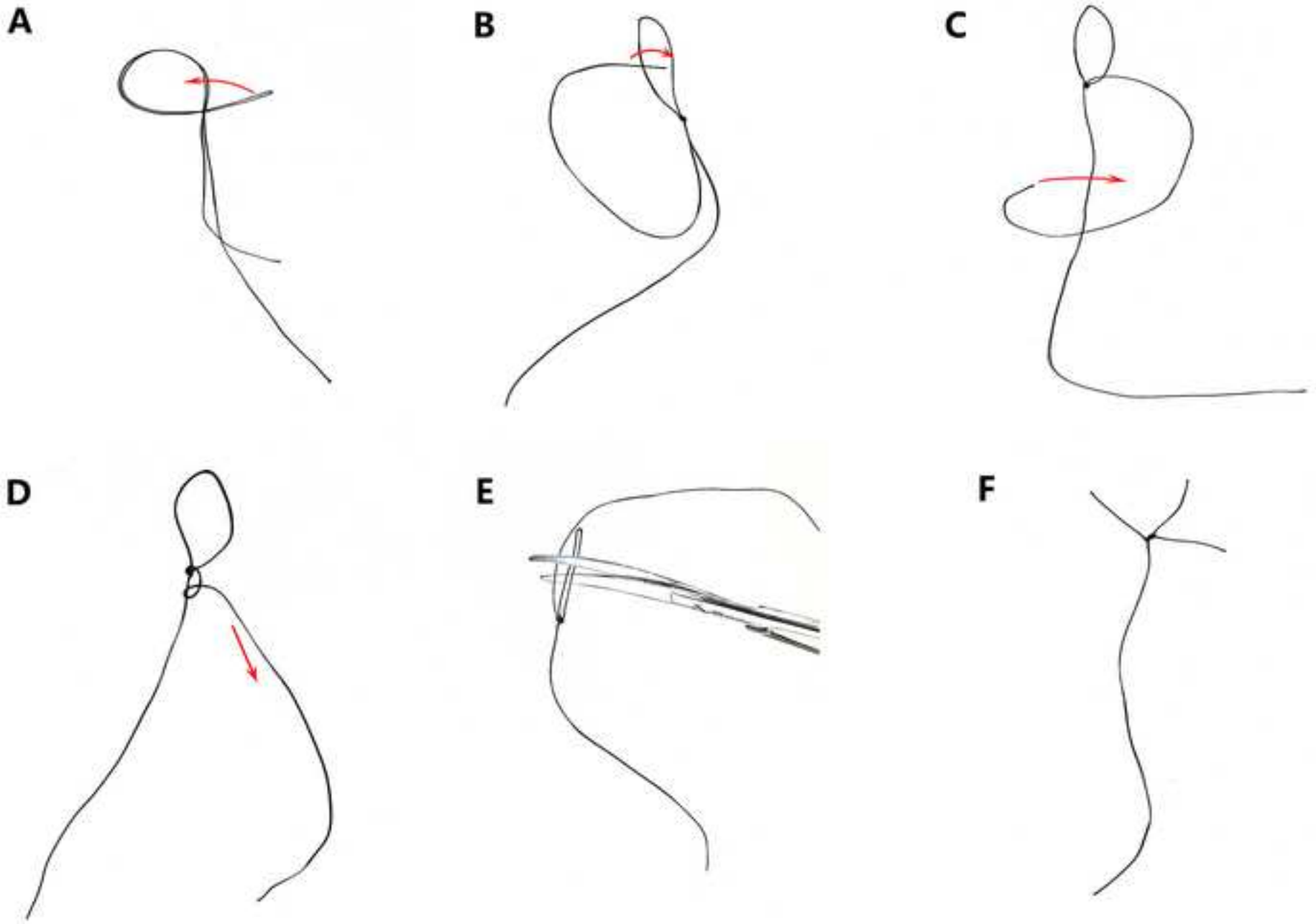

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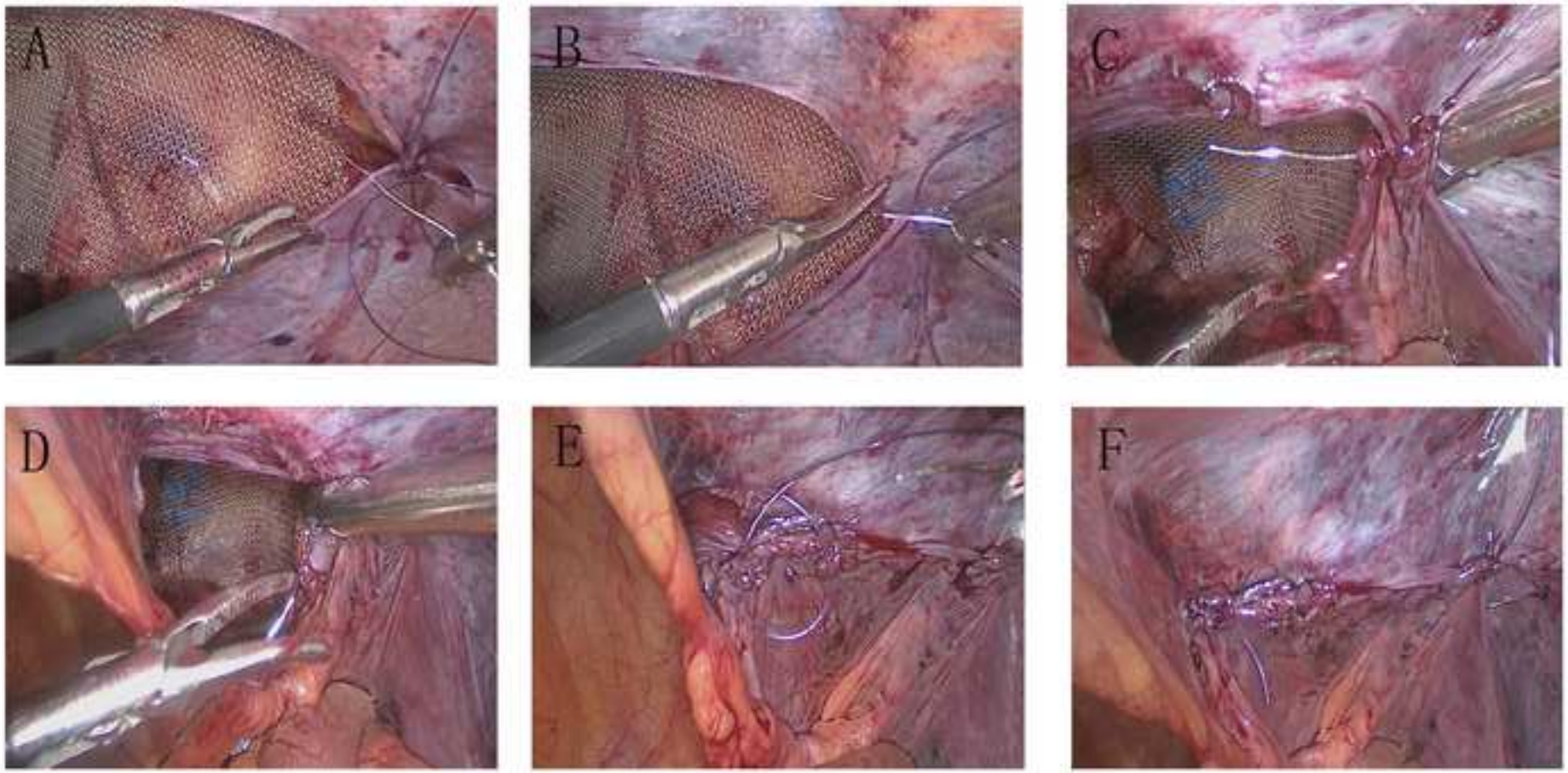

Table 1

	experimental group n = 134	control group n = 130	
Age (years)	54.3 ± 3.8	53.6 ± 4.7	0.18
Gender (*n*)			0.99
Men	98	95	
Women	36	35	
BMI (kg/m^2)	23.9 ± 2.3	23.5 ± 2.2	0.15
hernia type			0.28
Indirect hernia	87	76	
Direct hernia	47	54	
hernia sac treatment			0.49
Complete stripping	66	54	
Transverse	68	66	

Table 2

	experimental group n = 134	control group n = 130	P-value
suture times (min)	5.5 ± 0.9	11.7 ± 1.5	＜0.05
operation times (min)	47.6 ± 2.8	55.4 ± 2.3	＜0.05
recurrence of hernia	0	0	0.76
mesh infection	0	1	0.98
seroma	2	3	0.97
VAS score※	3.8 ± 0.8	3.7 ± 0.7	0.28
Length of hospital stay（days）	4.6 ± 1.2	4.8 ± 1.1	0.15
hospitalization cost(yuan)	11435.6 ± 712.5	11698.8 ± 733.3	＜0.05

VAS score：Visual Analog Score

Dear Dr. Iyer,

Thank you very much for your letter and advice. We have revised the manuscript, and would like to re-submit it for your consideration.

With regard to video shooting, according to the current epidemic prevention policy, the number of foreign personnel entering the operating room cannot exceed 2 at a time, and 72 hours of nucleic acid negative certificate shall be provided. Of course, we can also record according to the specific requirements of video shooting, and then send the edited video to you. In addition, the main shooting content of the video is the production of straight needle three tail knot and the suture of peritoneum, that is, Part 2 and Part 3 of the protocol. Some steps and pictures in the text have been modified as required.

I look forward to hearing from you soon.

With best wishes,

Yours sincerely,

Tai-cheng Zhou